Step-Length Dependency for the Calorimeter Responses

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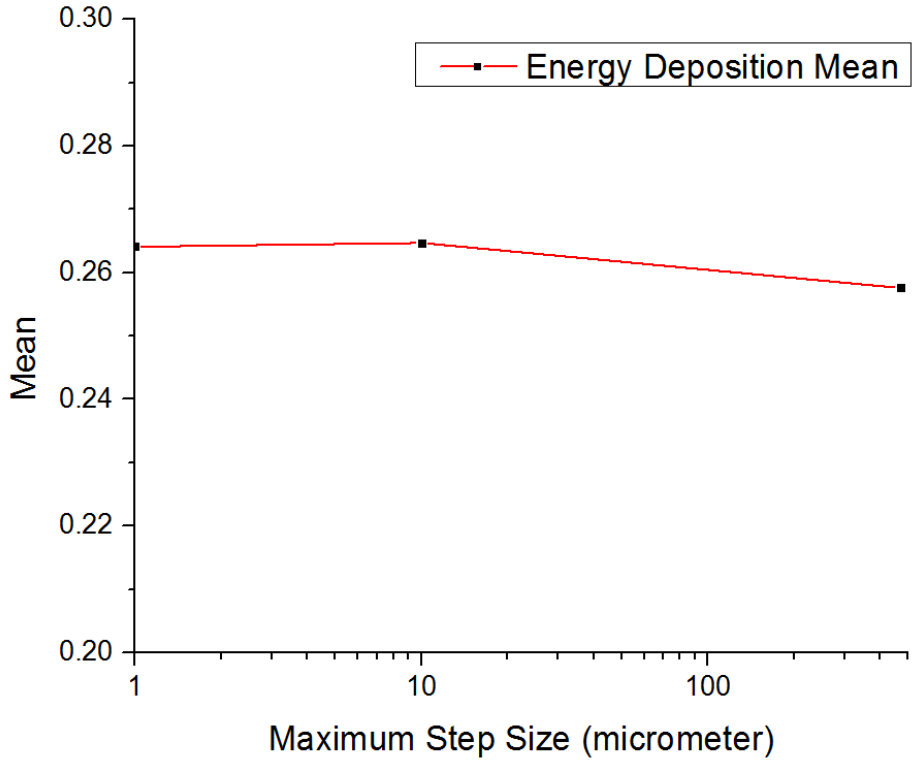
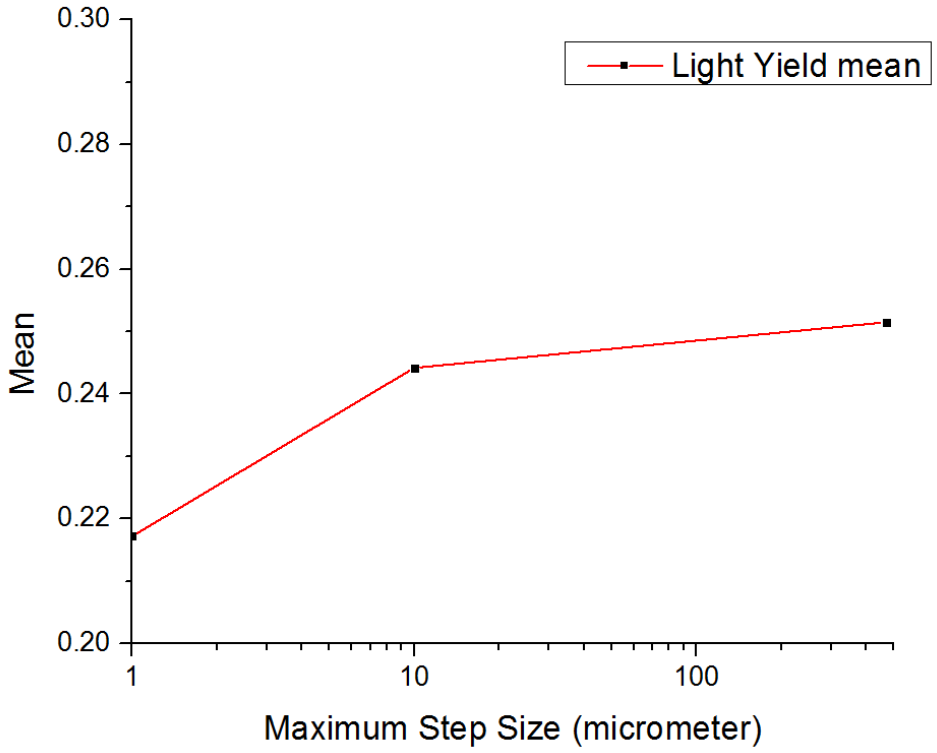
Previously

- Motivation: To study the dependency of the energy deposition and the light yield on the maximum step size in Geant4.

Previously

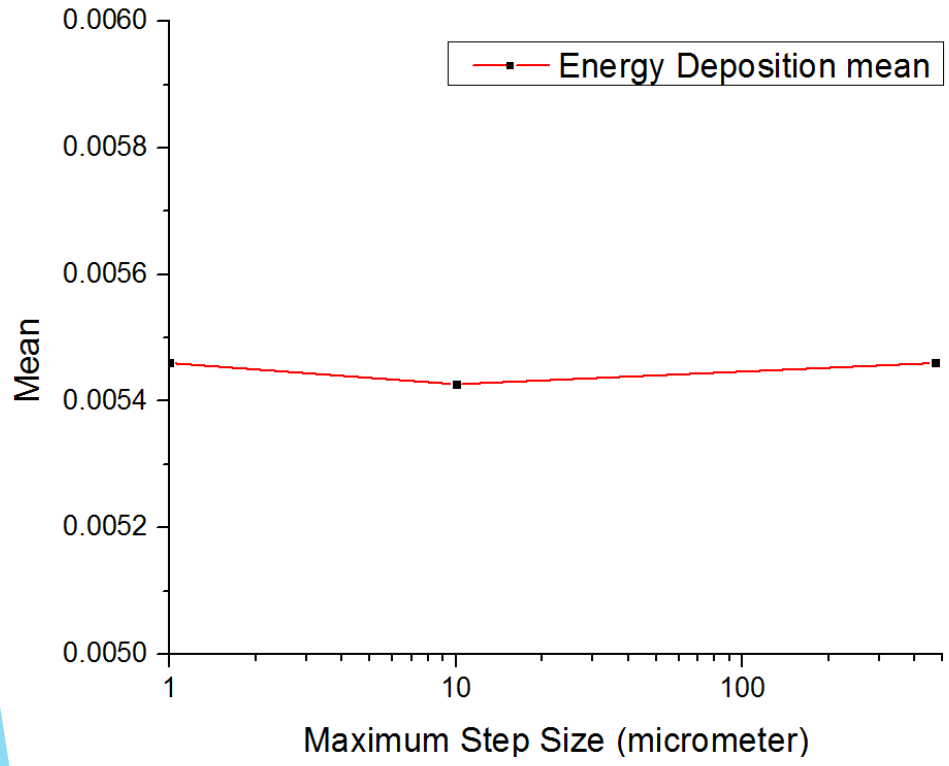
- Results for Electron

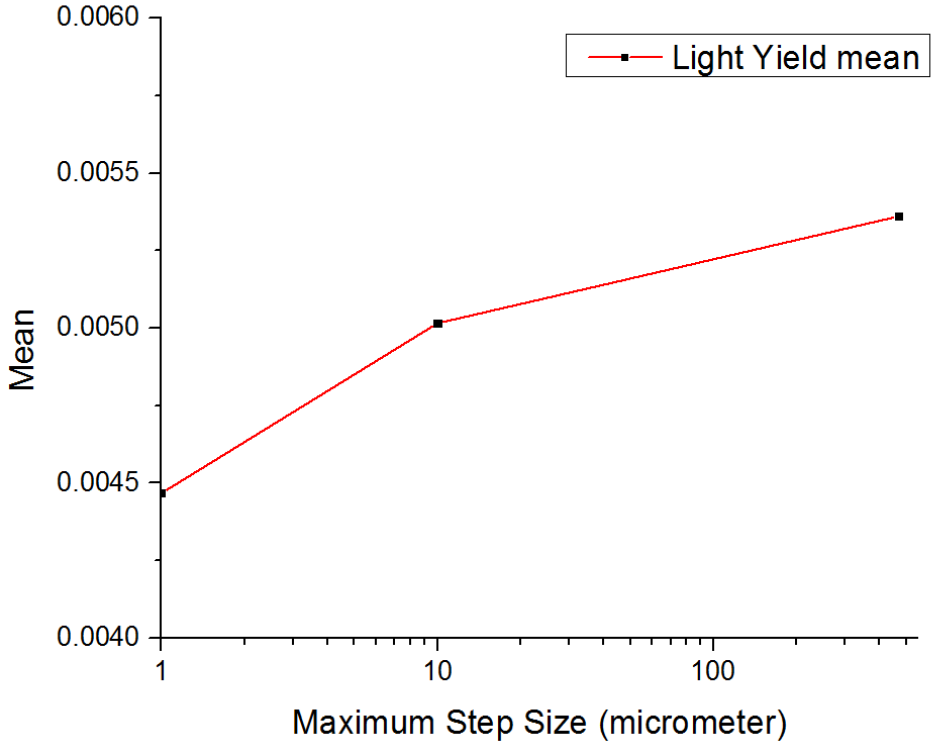




Previously

- Muon Results





Geant4 light yield calculation vs. our own calculation

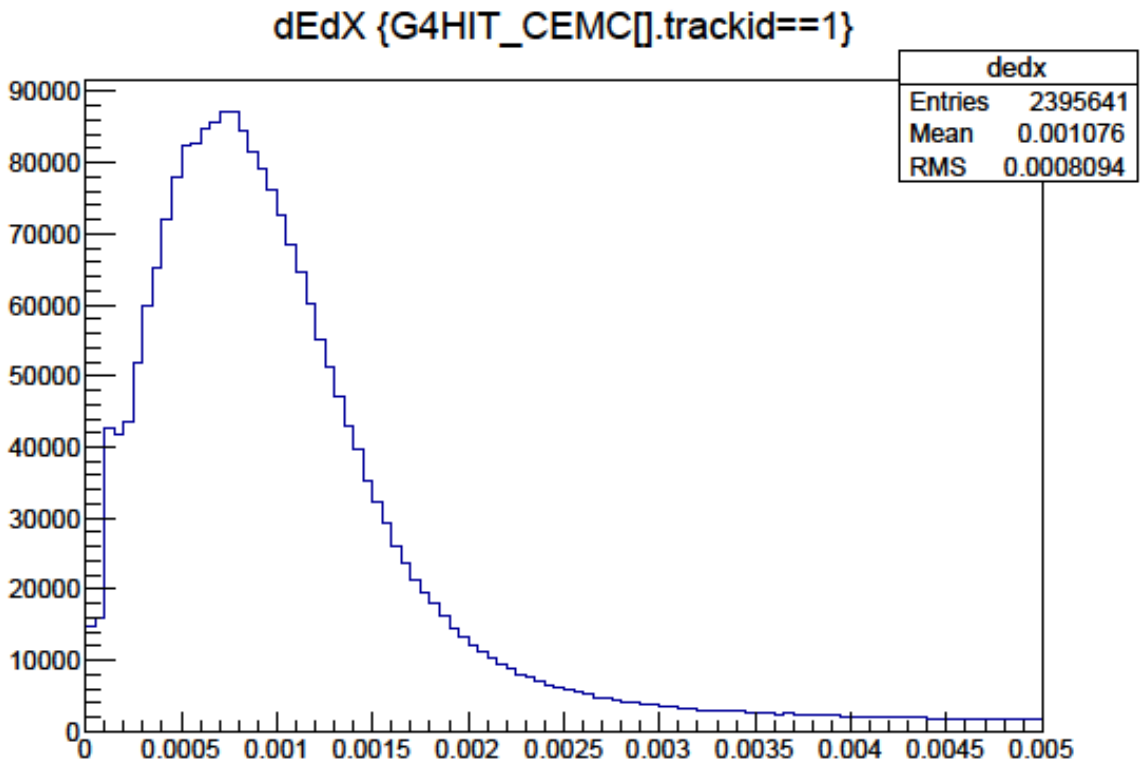
- We found out that the light yield by Birks Law calculated by Geant4 is equal to our own calculation.

- Birks Law formula:

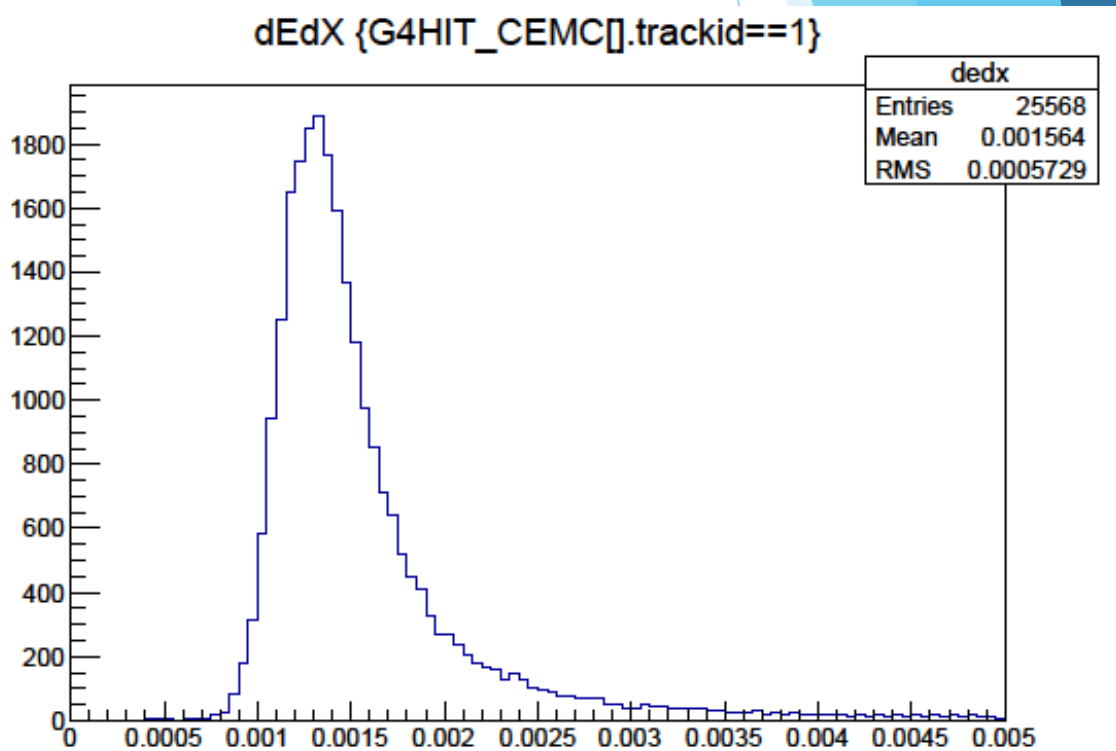
$$dS/dr = (A\ dE/dr)/(1+kB\ dE/dr)$$

Why is there a large Light Yield dependence on step length?

Step Length = 1 micrometer



Step Length = 100 micrometer



The light yield dependency on step length is due to the increasing fluctuation of dE/dx with small step lengths.

Minimum Step Length

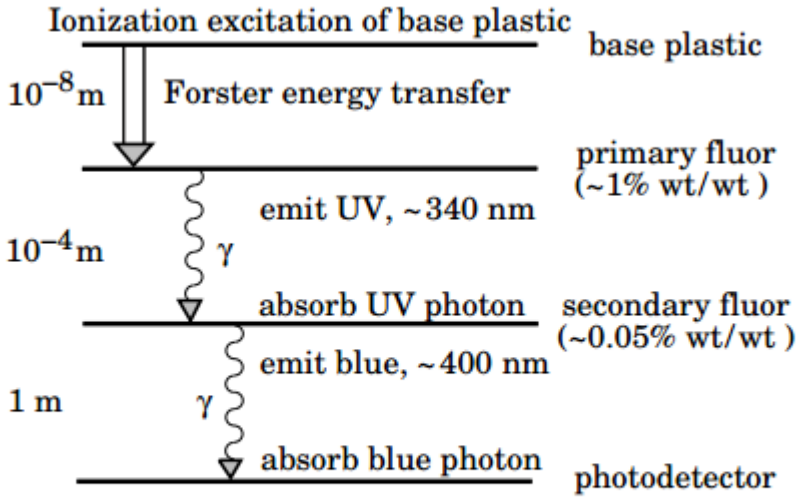


Figure 33.1: Cartoon of scintillation "ladder" depicting the operating mechanism of organic scintillator. Approximate fluor concentrations and energy transfer distances for the separate sub-processes are shown.

- We learned that the relevant length scale for saturating secondary fluor is ~ 100 μm.

New Goal

- At this point, we have a new goal: Performance Stability vs Step Length in 50-400 μm range. We focused in three studies:

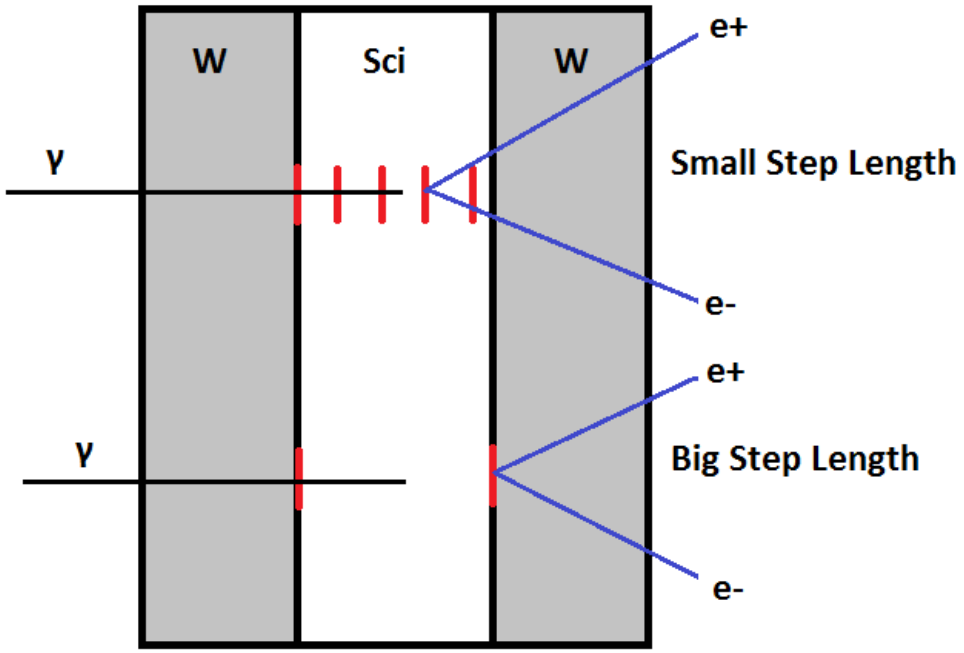
1. Energy deposited on emcal by electrons as function of Step Length
2. Ligth Yield on emcal by electrons as function of Step Length
3. The ratio of pions that passed the cut of 80% of Light Yield by electrons

Energy deposited on emcal by electrons as function of Step Length

- Goals:

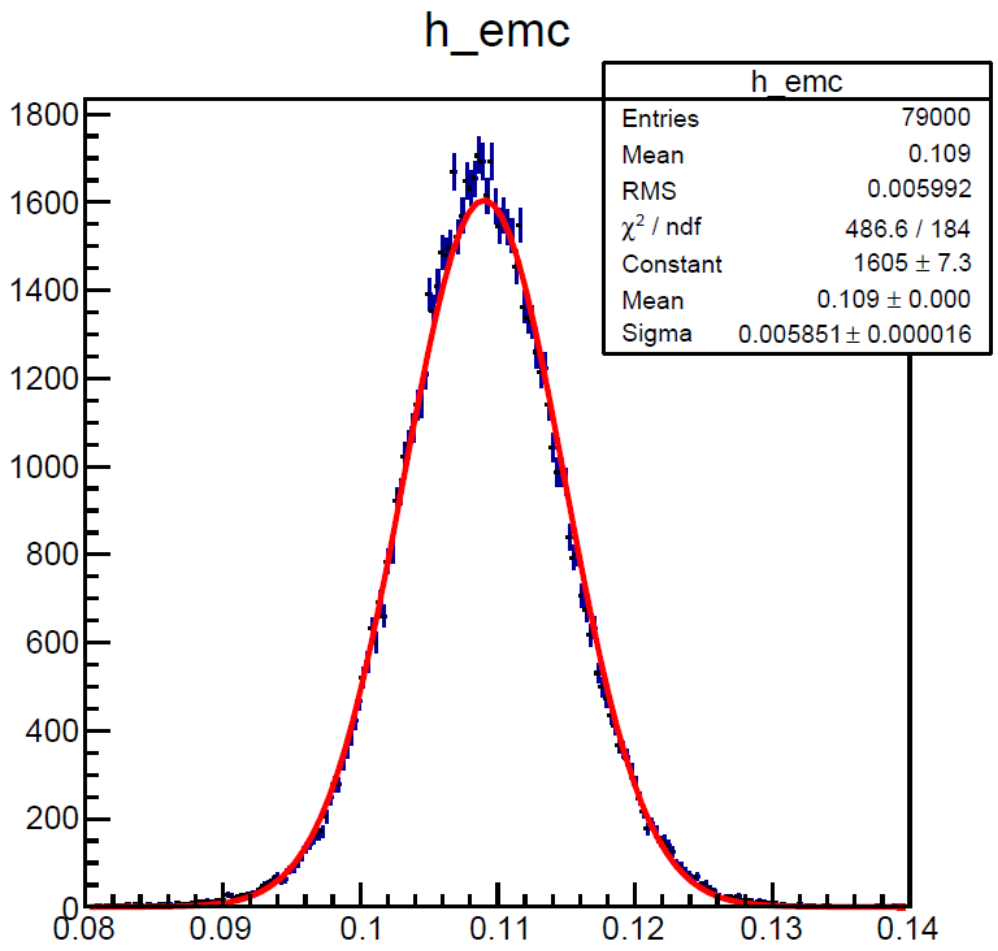
1. To check the code consistency.

2. Shower development vs. step length

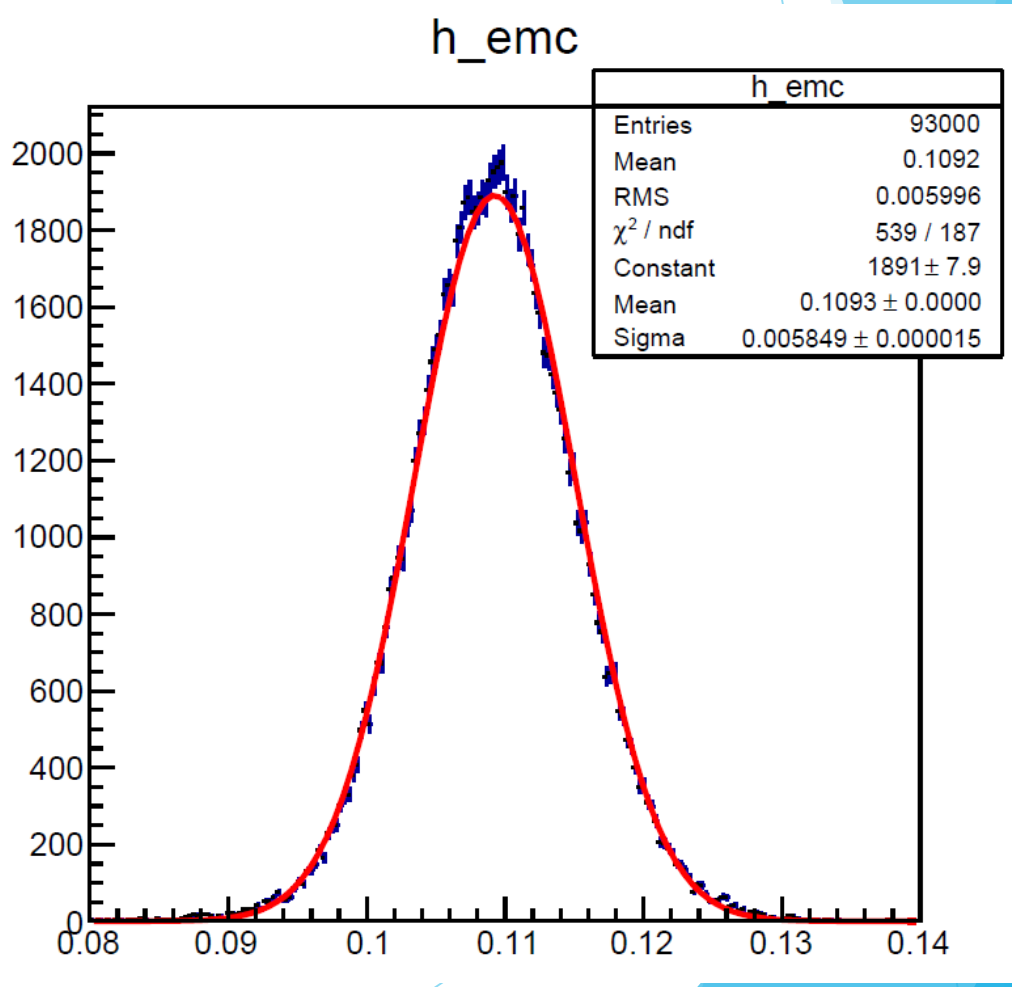


Results for Electrons

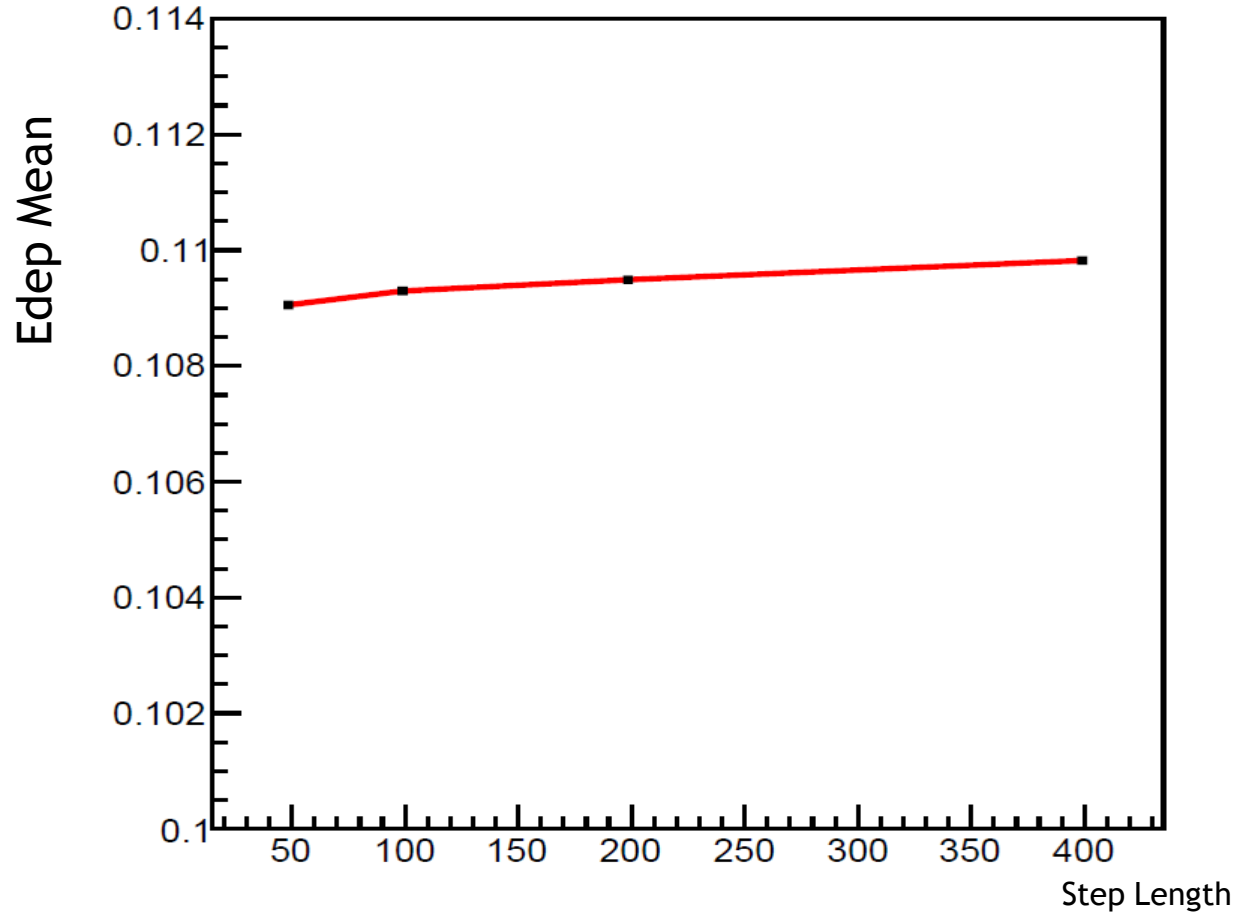
Step Length = 50 um



Step Length = 100 um



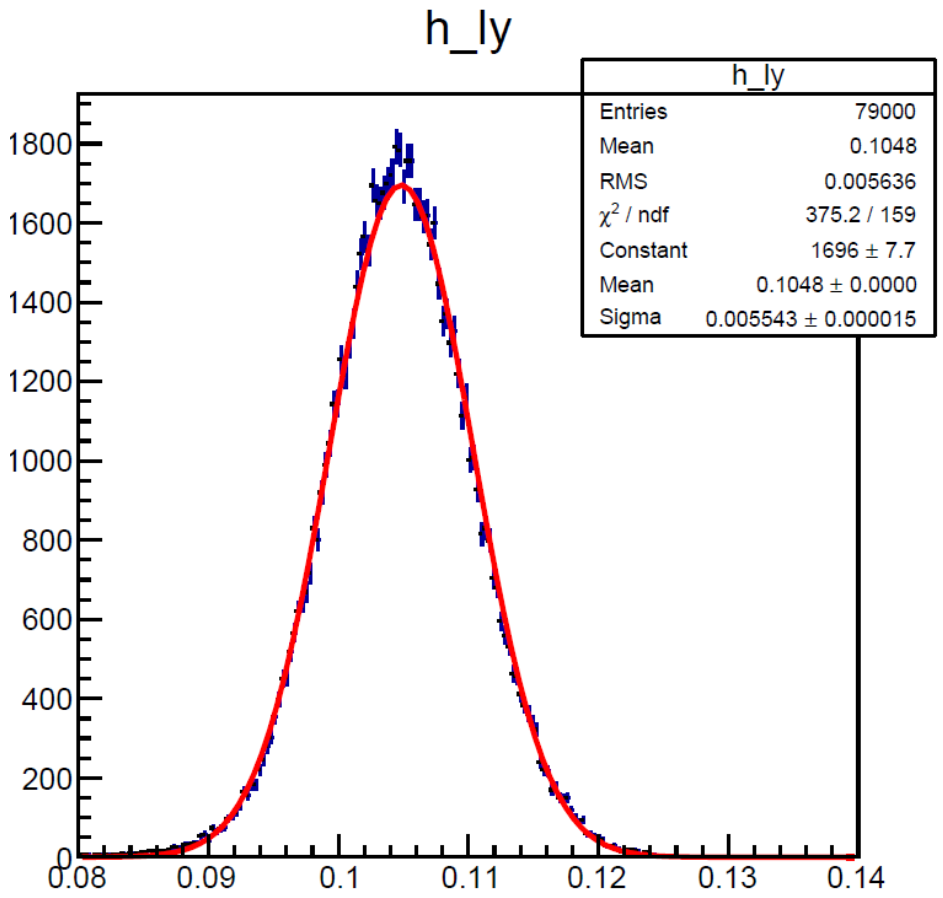
Energy Deposition Mean vs Step Length



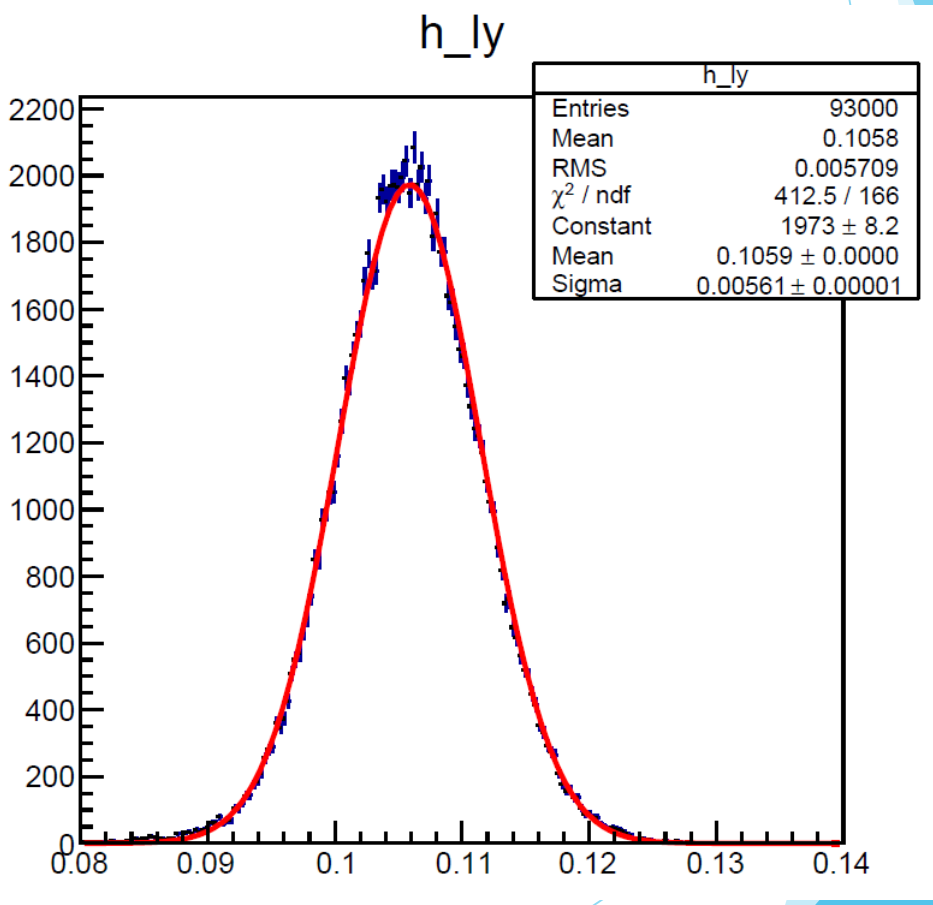
- We can observe a very small dependency of Energy Deposition Mean on Step Length and this suggest a minor dependency between step length and how Geant4 model EM-Shower in SPACAL.

Ligth Yield on emcal by electrons as function of Step Length

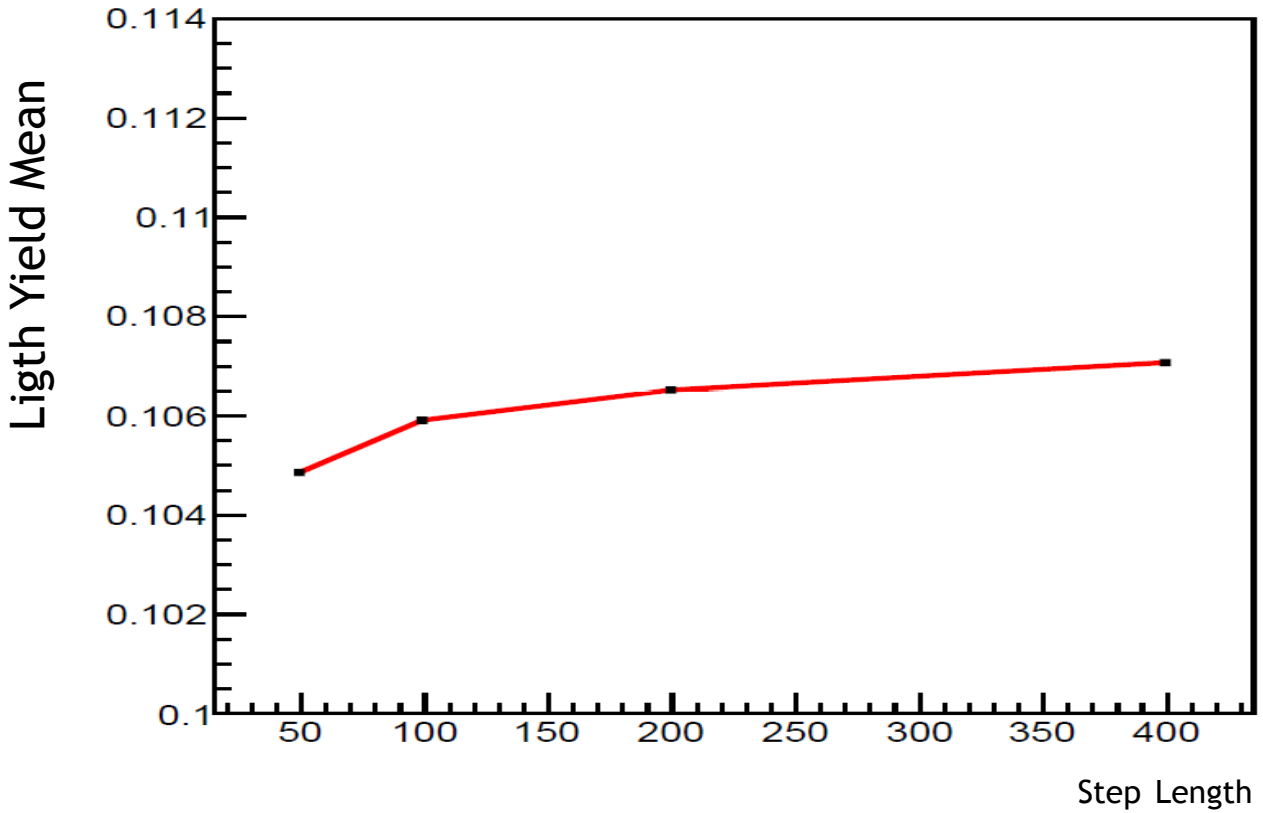
Step Length = 50 um



Step Length = 100 um



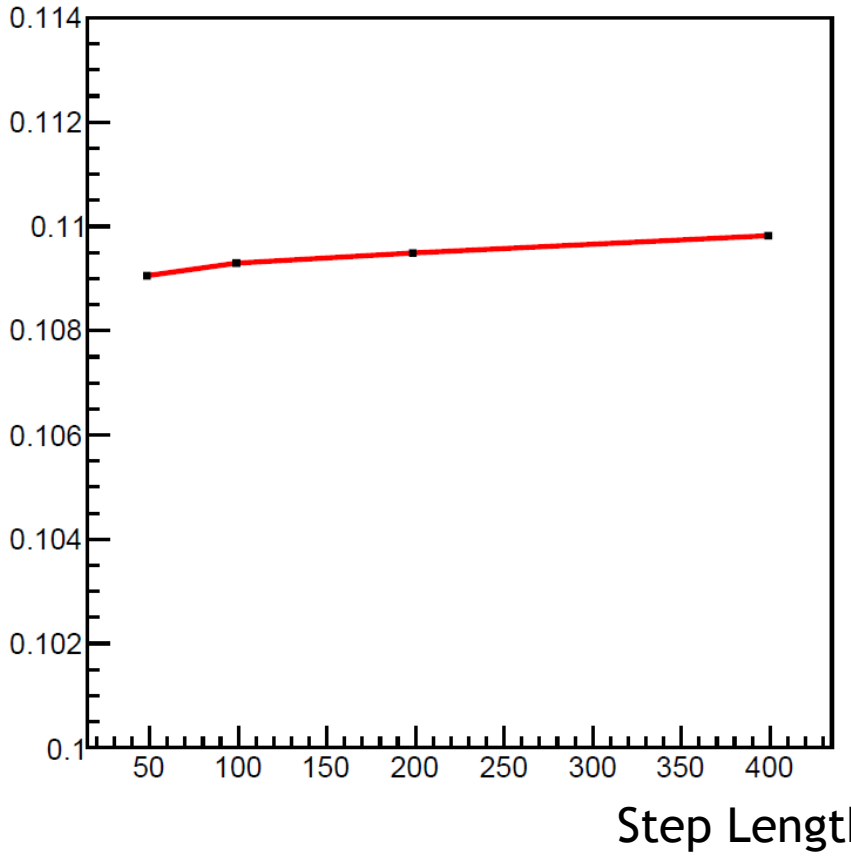
Ligth Yield Mean vs Step Length



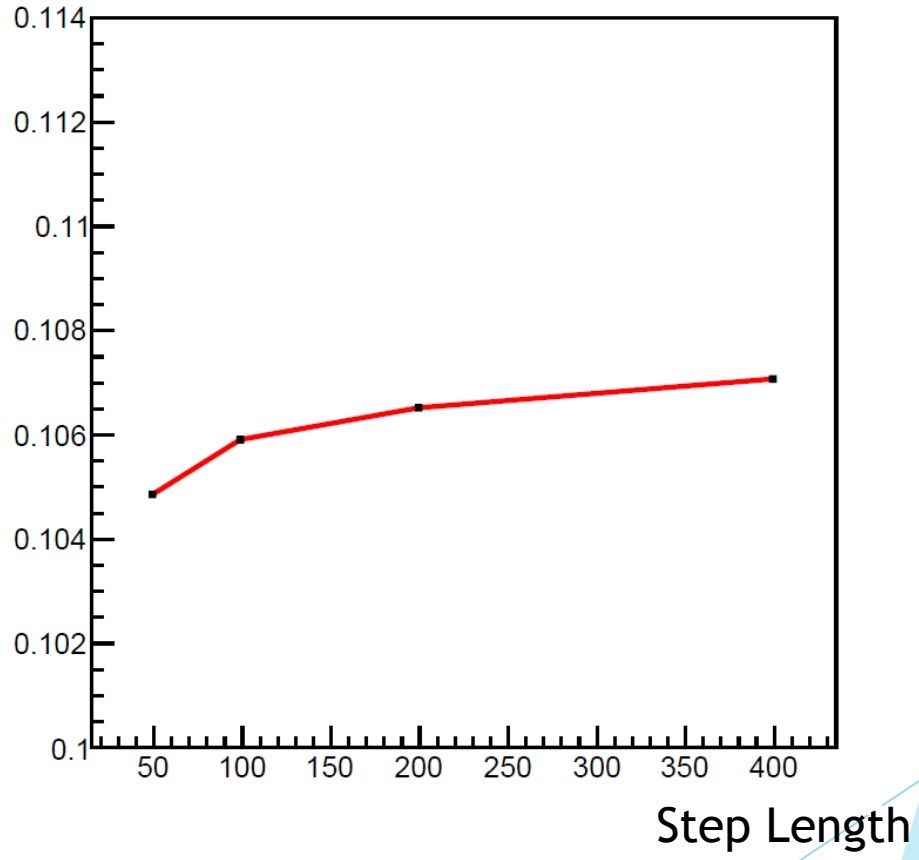
- We can observe a variation of Light Yield Mean caused by Birks non-linear dependency on step length.

Energy Deposition and Ligth Yield Mean

Energy Deposition Mean x Step Length

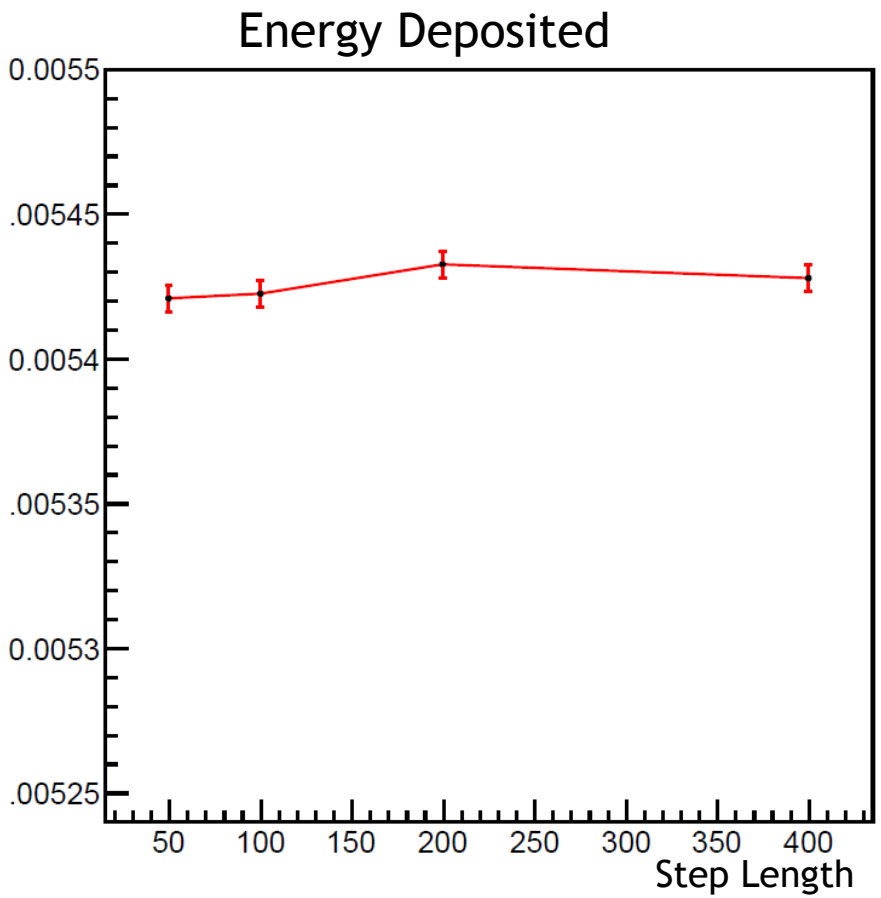


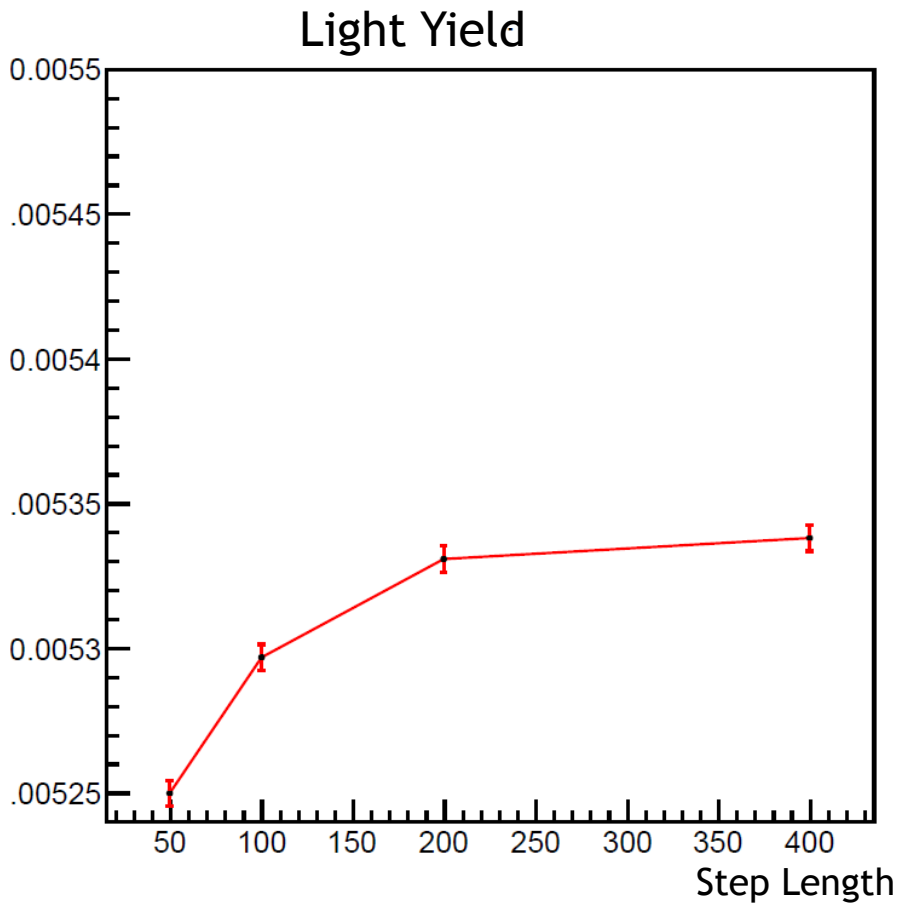
Light Yield Mean x Step Length



The light yield dependency on Step length is bigger than the Energy Deposition dependency on Step Length.

Results for Muons





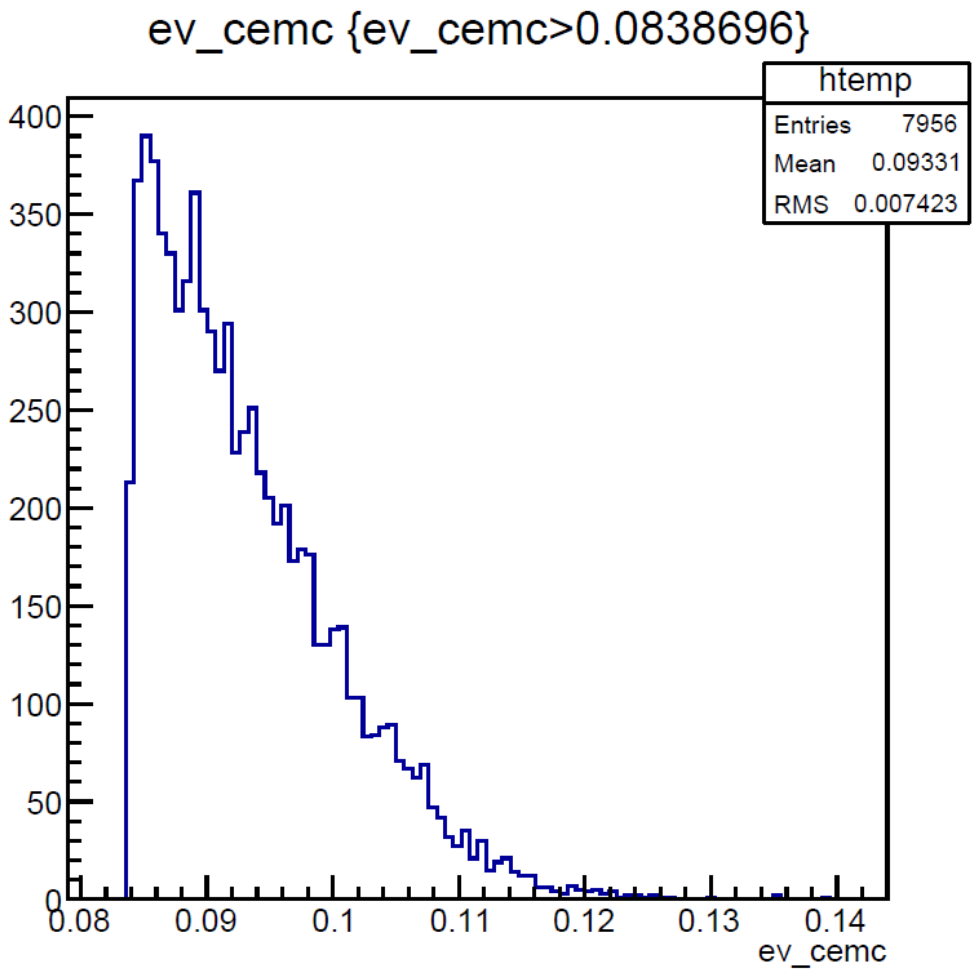
- Even though the Energy Deposited Mean suffer some fluctuation, it seems the mean does not really depend on the Step Length.
- Therefore, I would say that the variation for electrons is due to the modelling of EM-Shower.

The ratio of pions that passed the cut of 80% of Ligth Yield by electrons

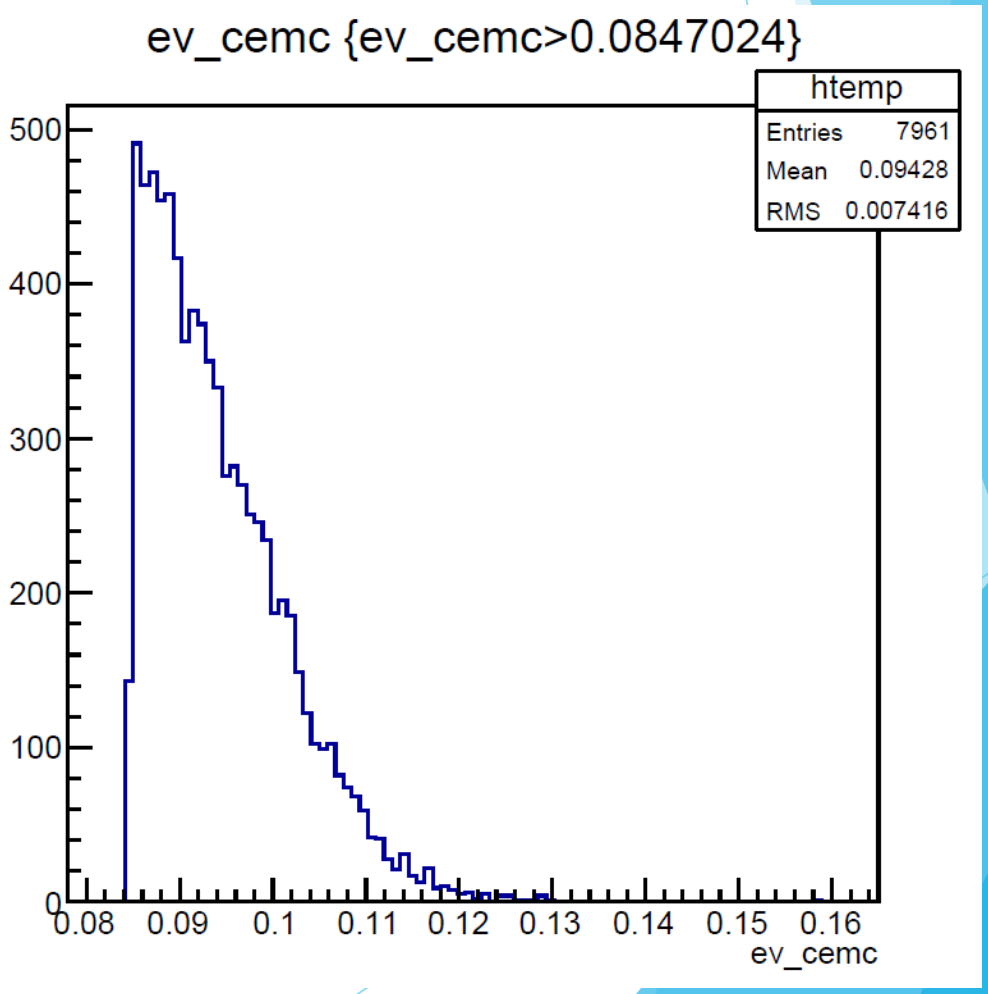
- Our goal is: Check the handle of stopped hadrons in the scintillator.
- We plot the percentage of pions that passed the cut VS Step Length.
- If variation is small, we conclude it is also safe to use the choice of 100 μm

Results for Pions

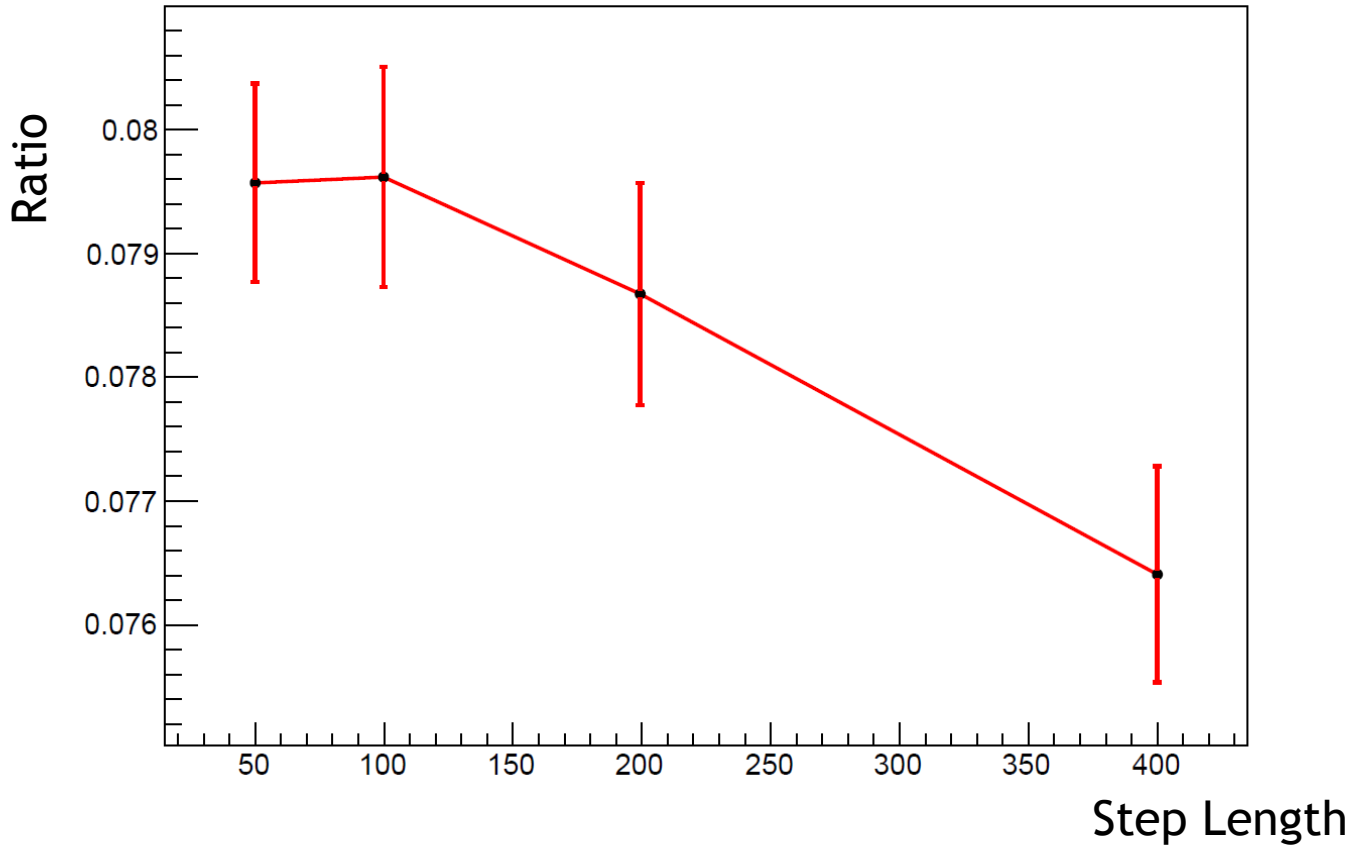
Step Length = 50 μm



Step Length = 100 μm



Results for Pions



The ratio of pions passing the cut is getting lower when step length increases, then again we suggest that it is important to set the step length to 100 μm in order to model the shower correctly.

Summary

- 1. Muon Energy Deposition says we sum up energy in small step sizes well.
- 2. Electron Energy Deposition says we need small step sizes to model EM shower in SPACAL well.
- 3. Electron's Light Yield and ratio of Pions passing the Light Yield cut says that we also need to limit the Step Length to model the light correction well.

What is next?

- To study pion shower in all three calorimeters.
- Submit the code which enables to set the step length limit for sPHENIX simulation.